INDOOR AIR QUALITY ASSESSMENT

Waterford Street School
62 Waterford Street
Gardner, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
June 2004

Background/Introduction

At the request of Bernie Sullivan, Health Director, Gardner Board of Health and the Gardner School Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Waterford Street School (WSS), 62 Waterford Street, Gardner Massachusetts. BEHA staff had previously visited the building in September of 2002 to provide technical assistance regarding IAQ issues stemming from a fire in the art room (MDPH, 2002). Reports of odors emanating from mechanical ventilation equipment in classroom 23 prompted this most recent request.

On January 21, 2004, Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an indoor air quality assessment. Mr. Holmes was accompanied by Paul Schaefer, Business Administrator, Gardner Public Schools.

The WSS is a two-story, brick building that was constructed in 1953. No major renovations have reportedly taken place in the building. The second floor contains general classrooms. The first floor contains general classrooms, the kitchen, cafeteria/auditorium, library, music room, art room, specialty rooms, teacher's room, boiler room and office space.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The building houses approximately 550 students in grades pre-K through two and a staff of approximately 80. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from the Table 1 that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in one of thirty-two areas surveyed, indicating adequate air exchange in the majority of areas, on the day of the assessment. The area with an elevated carbon dioxide level was a small office that lacked mechanical ventilation. It is also important to note however, that several areas were unoccupied or sparsely occupied, which can greatly reduce carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks placed in front of univent returns were noted (Picture 2). In order for univents to provide fresh air as designed, intakes must remain free of obstructions. Importantly, these units must remain activated and allowed to operate during periods of occupancy.

Exhaust ventilation in classrooms is provided by a mechanical system. The exhaust system in each classroom consists of ducted, grated wall vents. Rooftop motors create flow, which aids exhausting of classroom air. A number of the exhaust vents were blocked by furniture and other items (Picture 3). As with the univents, in order to function properly, exhaust vents must remain free of obstructions.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to Mr. Schaefer, the supply and exhaust ventilation system was last balanced approximately a year prior to the assessment and that due to the age of equipment, balancing is an on-going project. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 68 ^{o} F to 76 ^{o} F, which were close to the BEHA comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 11 to 18 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Classroom 23 Odors

As discussed, the primary focus of this assessment was to investigate and identify the source of odors in classroom 23. Occupants believed the odors were emanating from the univent. The room had been vacated and had been empty for two weeks prior to the BEHA assessment. Mr. Schaefer reported that the following repairs/maintenance were made to the univent: the fan motor was replaced; the interior and exterior surfaces were cleaned and filters were changed. In addition, faulty bearings within the univents were scheduled to be replaced. BEHA staff examined the univent for steam/fuel leaks, accumulated moisture, visible microbial colonization and other point sources of contamination. Both the interior and filters of the univent were clean. No leaks, accumulated moisture or other possible accumulated pollutants were observed within the univent interior. BEHA staff examined the univent operating under a number of conditions. At various times during the assessment, the univent was operated at low and high speed and with the fan deactivated. No odors were detected while operating the univent at low or high speed. When the univent fan was deactivated, a steam/moist-type odor was detected. Mr. Schaefer confirmed that this odor was identical to the odor that prompted this assessment. This was also confirmed by a previous occupant that was familiar with the odor. BEHA staff reactivated the univent fan and the odor dissipated.

As discussed in the Ventilation section of this report, univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building. When the fan is deactivated, fresh air cannot be introduced to temper the radiant heat generated by the univent heating coils. At the time of the assessment, BEHA staff recommended that the univent fan remain on and that the timer be adjusted to activate one to two hours prior to the building being occupied. In a subsequent phone conversation, Mr. Schaefer reported that the timer was adjusted, bearings were replaced and that the univent fan was operating as recommended. The occupants were moved back into the room and no further symptoms or odor complaints were reported.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions of reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000).

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. *Carbon monoxide should not be present in a typical, indoor environment.* If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels.

The NAAQS originally established exposure limits for particulate matter with a diameter of 10 µm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter (µg/m^3) in a 24-hour average. This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 μg/m^3 over a 24-hour average. Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 5 μg/m^3 (Table 1). PM2.5 levels measured indoors ranged from 4 to 12 μg/m^3. Although PM2.5 measurements were above background in some areas, they were below the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were also ND (Table 1).

Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products. While no TVOC levels measured exceeded background levels, materials containing VOCs were present in the school.

The faculty workroom contains photocopiers and lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). Occupants should ensure that local exhaust ventilation in this area is operating while equipment is in use to help reduce excess heat and odors. Cleaning products were found on countertops and beneath sinks in a number of classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 4). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and to off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Of note was the amount of materials stored in some classrooms. Items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Finally, an open utility hole in the wall of the main office and open utility holes in floors of univents were observed (Pictures 5 and 6). Open utility holes can provide a pathway for the movement of drafts, dusts and particulate matter between rooms and floors.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Continue to operate mechanical ventilation systems (e.g., gym, cafeteria, classrooms) continuously during periods of school occupancy to maximize air exchange.
2. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Consideration should be given to reconfigure the layout of some classrooms to facilitate airflow.
3. Continue with on-going efforts to balance the mechanical ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is

recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

5. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
6. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
7. Store cleaning products properly and out of reach of students.
8. Seal utility holes in the main office and in univent cabinet interiors.
9. Consider discontinuing the use of tennis balls on chairs to prevent latex dust generation.
10. Consider adopting the US EPA document, "Tools for Schools" to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.
11. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

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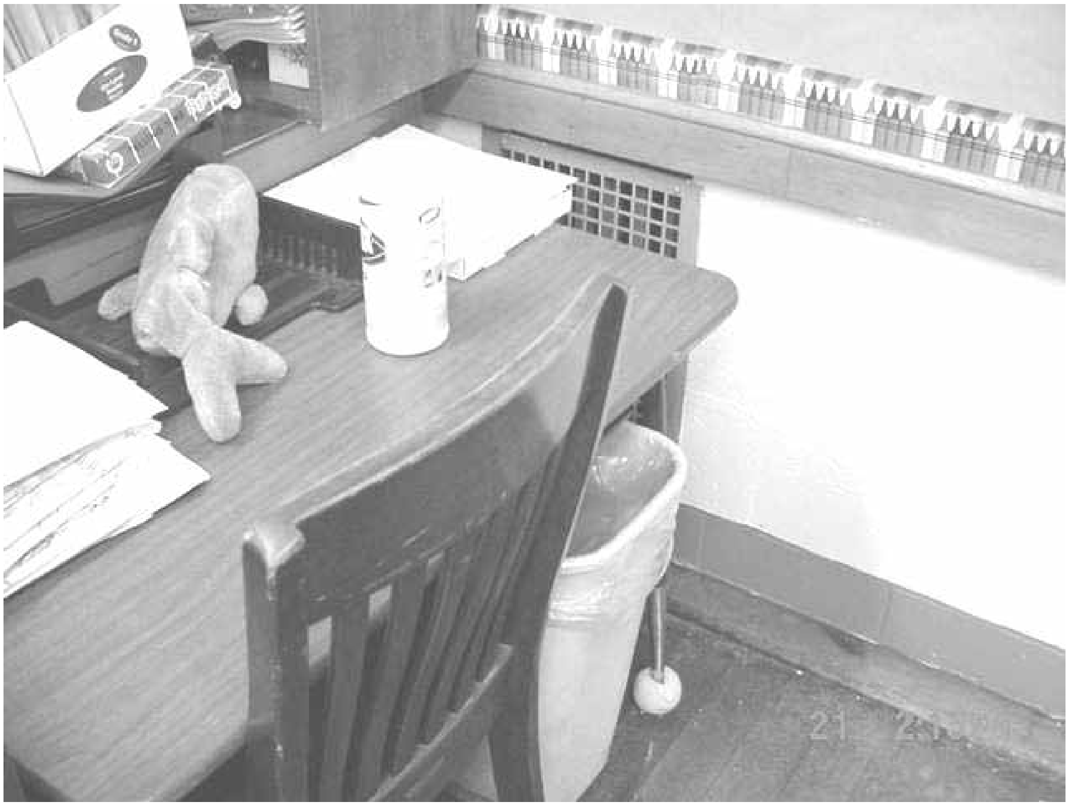
Picture 1

Typical Classroom Univent 1950's Vintage

Picture 2

Univent Return Vent Obstructed by Various Items

Picture 3



Classroom Exhaust Vent Obstructed by Table and Other Items

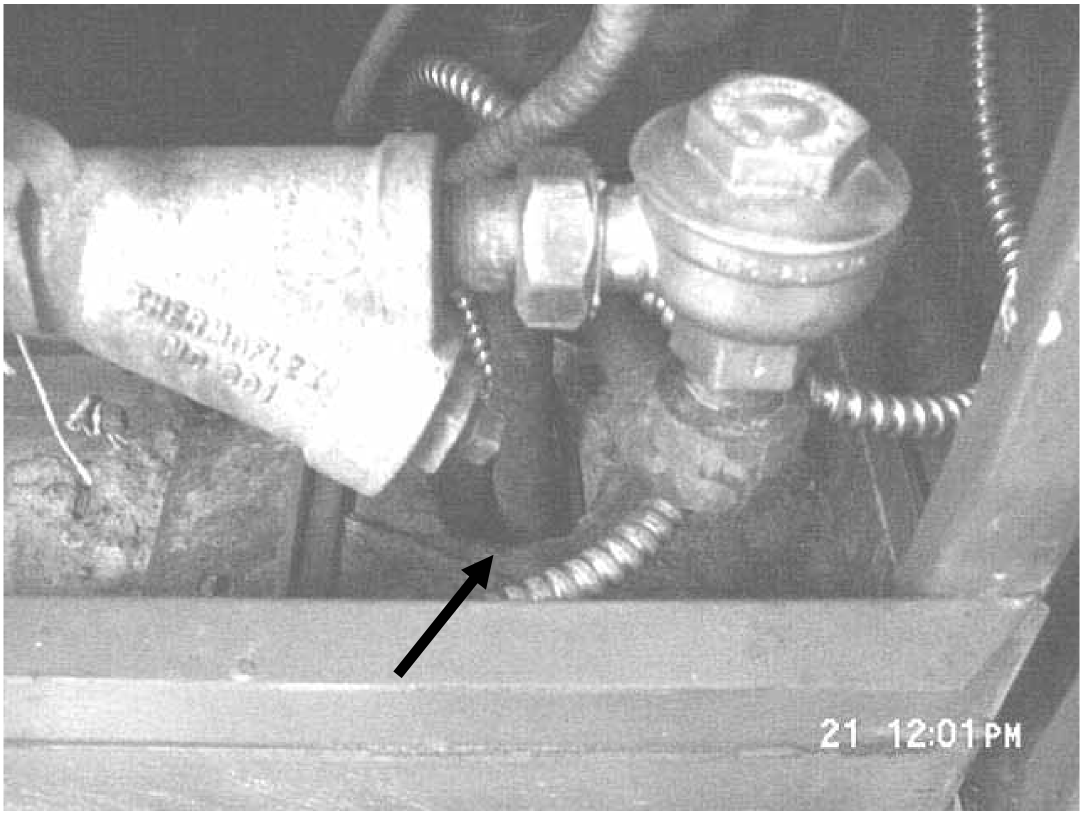
Picture 4

Tennis Balls on Chair Legs

Picture 5

Open Hole in Wall (Main Office) Near Photocopier

Picture 6



Open Utility Hole in Floor of Univent Cabinet

Building: Waterford Street School
Address: Gardner, MA

Indoor Air Test Results
Date: 01/21/04

TABLE 1

Location/Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	CO (ppm)	TVOCs (ppm)	PM (μg/m³)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background		33	13	337	ND	ND	5				Winds SW 10-20 MPH, Mostly cloudy, Cold
23	0	68	12	341	ND	ND	5	Y	Y	Y	CD, ~ 10:30 am UV-dry no signs of leaks, filter changed over Christmas vaca, open utility holes, room unoccupied two weeks, UV deactivated upon exit by BEHA/GPS staff
24	0	70	13	556	ND	ND	6	Y	Y	Y	Exhaust blocked by clutter, ~20 occupants gone 5 minutes, TB, DEM, Plants
22	0	71	13	542	ND	ND	7	Y	Y	Y	DEM, Supply blocked by clutter and furniture, Exhaust blocked by furniture, 22 occupants gone half hour, Area carpets, recommend reconfiguring classroom to facilitate airflow

ppm = parts per million parts of air

AD = air deodorizer
AHU = air-handling unit
AP = air purifier
AC = air conditioning
CD = chalk dust

AC = air conditioner
UV = univent
CT= ceiling tile
DEM = dry erase marker
DO = door open
MT= missing ceiling tile
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water damage
ND = non-detect

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

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									Supply	Exhaust	
3	11	73	13	548	ND	ND	10	Y	Y	Y	
2	24	72	18	795	ND	ND	9	Y	Y	Y	Exhaust blocked by clutter and furniture, Cleaners
Cafeteria	~125	71	17	687	ND	ND	9	Y	Y	Y	
11	2	71	16	690	ND	ND	6	Y			
23	0	70	14	528	ND	ND	8		Y	Y	~12:30, UV off 2 hours, Heat-steam odors, Bearings will be replaced, UV reactivated upon exit by BEHA/GPS staff
Conference RM	0	69	18	538	ND	ND	4	Y			Window AC, Dusty Odor
Readiness RM	15	72	17	674	ND		7	Y	Y	Y	Nests, Supply blocked by furniture, Exhaust blocked by furniture
Resource RM (2nd Grade)	6	71	15	506	ND	ND	6	Y	Y		Nests, Supply blocked by clutter

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									Supply	Exhaust	
18	5	70	17	689	ND	ND	9	Y			DEM
Main Office	3	71	17	784	ND	ND	8	Y			Plants, Eye/throat irritation, Open utility holes, 2 photocopiers, AC
Mc Faul	22	72	17	531	ND	ND	9	Y	Y	Y	Supply blocked by clutter and furniture, Exhaust blocked by furniture
Gym	12	69	14	451	ND	ND	8	N	Y	Y	
Library	10	70	18	654	ND	ND	8	Y	Y	Y	Supply blocked by furniture, Feather duster, Exhaust could not be identified
Principle's Office	3	76	18	883	ND	ND	9	Y	N	N	
Pre-K Wing				470	ND	ND	12				Boiler room odors, Boiler room door open, Exhaust door open, Pressurized

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14	21	70	16	600	ND	ND	8	Y	Y	Y	TB, DEM, Plants, Supply blocked by furniture, Exhaust blocked by furniture
15	23	71	17	695	ND	ND	9	Y	Y	Y	TB, Plants
16	2	72	16	560	ND	ND	7	Y	Y	Y	DEM, 15 occupants gone 5 minutes
13	2	70	14	475	ND	ND	6			Y	22 occupants gone 10 minutes, Exhaust blocked by furniture, TB, Cleaners
1	14	71	12	529	ND	ND	8	Y	Y	Y	UF, Plants
23	0	69	11	386	ND	ND	8	Y	Y	Y	~ 2:00 pm UV on low, No odors
29	19	71	16	761	ND	ND	8	Y	Y	Y	Cleaners, Plants, Supply blocked by furniture, Exhaust blocked by clutter

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20	22	71	15	734	ND	ND	9	Y	Y	Y	Supply blocked by clutter and furniture
Henderson	5	71	16	573	ND	ND	10	Y	Y	Y	PF, Exhaust blocked by clutter and furniture
Nurse's Office	2	73	18	730	ND	ND	10	Y			PF, Cleaners
Reading RM	2	71	17	768	ND	ND	7	Y			
27	20	70	14	735	ND	ND	7	Y	Y	Y	UF, PF, Cleaners, Area carpet
25 (Computer Lab)	19	70	13	580	ND	ND	6	Y	Y	Y	Plants, 24 Computers, Window AC
Teacher's WK RM	0	70	16	666	ND	ND	6			Y	Lamination photocopier

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